Annual Reports for 1949-51 of the Soils Division of the Rubber Research Institute of Malaya

RUBBER RESEARCH INSTITUTE OF MALAYA
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PREFACE

IT HAS BEEN THE CUSTOM to publish annually the reports of the several Divisions of the R.R.I. together with an introductory survey by the Director.

During the period of recovery after the war, publication of progress reports was delayed. The reports of the Divisions from September 1945 to the end of 1948 were issued as a single publication. Separate publications on specific subjects of research have continued to appear as Communications to the Journal of the R.R.I., but formal Annual Reports have not been published.

Postwar plans for research and development have crystallised and have been formally embodied in the Malayan Rubber Fund Five Years Plan 1949-53. The work of the R.R.I. since 1948 may therefore be reviewed in relation to the general research programme laid down for the five years.

These three reports are among a number which together will constitute a general report for 1949-51. The whole may thus be regarded as an interim report on the workings of the five years plan. The numbering of sections under the chapter heading INVESTIGATIONS is that adopted in the general research programme.

The Reports for 1949, 1950 and 1951 of the Soils Division are presented.

Director

SOILS DIVISION 1949

RUBBER RESEARCH INSTITUTE OF MALAYA
KUALA LUMPUR

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STAFF

ADDITIONS TO BOTH senior and junior staff had been made towards the end of 1948, but owing to leave arrangements and resignations the effective strength of the Division was not materially increased. The Soils Chemist (Mr G. Owen) was absent on long leave from 22 February until 13 September, one field assistant resigned owing to ill health early in 1949, and one field assistant was absent on long leave until April. From the end of September the staff consisted of three senior officers, nine laboratory assistants, eight field assistants, one laboratory attendant and one peon.

INVESTIGATIONS

I

SOIL SURVEY

Field examinations were made and soil samples from profile pits were taken whenever suitable opportunities arose during visits to estates. Over forty profiles were examined and sampled in sixteen different areas. Of particular interest was the examination in Selangor of a newly noted area of soil derived from dolerite material (Pahang Volcanic Series). Assembling and comparing data was commenced towards the end of the year as a preparation to publishing an account of Malayan soil types.

II

MANURING OF HEVEA

The principal field experiments on the R.R.I. Experiment Station and on estates continued without serious interruption. Bandit activity interfered with only three experimental areas, two being in Johore and one in north Selangor. One experiment on peat soil in a coastal district suffered such severe losses of trees in a heavy wind storm that it was abandoned. Fertiliser applications were given in nine experiments, completing the second application since 1947. Annual girth measurements were recorded in sixtynine manuring or replanting experiments, and at the end of the year monthly yield records were being provided from twentysix areas. A number of nursery manuring experiments are in progress at the Experiment Station.

EFFECT OF FERTILISERS ON GROWTH

The growth responses to fertilisers of young rubber trees up to early maturity have been reported in previous years for different groups of experiments, and in 1949 a comprehensive statistical examination was made by the Statistician of the growth data from twentythree experiments*. The main agronomical results† of these experiments are summarised below, and refer to girth measurements of trees six to eight years old, manures having been applied during the early years of growth from 1937 to 1941.

Phosphate fertilisers had the largest significant positive effect on inland soils of the types granite loams, clay loams and lateritic clay loams. A small positive response to nitrogen on the same soil types was observed but potash had no effect on growth. On the coastal alluvial clay soils, no response to nitrogen was recorded and only a very small girth increase resulted from phosphate manuring; the effect of potash was to retard growth slightly. The main indication for practice from these fertiliser effects on growth is that the minimum girth for tapping can be reached earlier by the use of phosphate fertilisers; if the attainment of maturity is advanced by a year, the value of the crop from the additional productive year will amply repay expenditure on early manuring.

The majority of the manuring experiments on estates have now reached a stage at which chief interest lies in study of the effects of fertilisers on young mature trees which have been in tapping for several years. Manuring treatments are being applied regularly every two years. Although considerable growth responses to fertilisers were recorded during the early life of these trees, the postwar measurements show no appreciable differences in the rate of growth under the different manuring treatments. At this stage further conclusions cannot be drawn from the experiments; a long series of yield records may be needed to reveal significant differences in response to the several treatments.

In TABLE I the summaries of girth measurements taken in 1949 are given, together with girth increments for 1948 to 1949, for the experimental areas of the Soils Division.

For twelve year old buddings of all clones an average annual girth increment of about 0.5 inches for trees of 27.0 inches girth was obtained, and for younger buddings aged 9 to 10 years, the average girth increment for 1948 to 1949 was just under an inch. The limits over which these increments ranged were from 0.6 to 1.3 inches.

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* *J. Rubb. Res. Inst. Malaya* 12 (1950) 127

† *J. Rubb. Res. Inst. Malaya* 12 (1950) 169

TABLE I: MEAN GIRTHS OF TREES IN SOILS DIVISION EXPERIMENTAL AREAS IN 1949
(in inches at 60 inches)

Year budded	*Clone PB 86*	*Clone Pil B84*	*Clone Tjir 1*	*All clones*
1937	26.61 (6)	27.92 (5)	28.81 (5)	26.94 (6)
1938	25.85 (8)	26.15 (5)	26.67 (9)	25.94 (10)
1939	25.10 (10)	25.78 (12)	26.58 (8)	25.70 (14)
1940	23.42 (1)	23.73 (3)	26.53 (2)	24.94 (4)
Mean	25.63 (25)	26.04 (25)	27.07 (24)	25.90 (34)
Replantings (1937-40)			26.45 (7)	25.35 (10)
MEAN GIRTH INCREMENTS 1948-1949				
1937	0.41 (6)	0.57 (5)	0.51 (5)	0.47 (6)
1938	0.97 (8)	1.07 (5)	1.01 (9)	0.95 (10)
1939	0.91 (10)	0.93 (12)	0.77 (8)	0.89 (14)
1940	1.20 (1)	1.08 (2)	1.05 (2)	0.99 (3)
Mean	0.82 (25)	0.90 (24)	0.83 (24)	0.83 (33)
Replantings (1937-40)			1.28 (4)	1.12 (7)

The figures in brackets indicate the number of experiments from which the mean girth is derived

Effect of fertilisers on growth of mature trees — The only old mature rubber trees under experimental manuring were those in Field 6 at the Experiment Station. These seedling trees, planted in 1928 on the extremely sandy soil of the flat areas at Sungei Buloh, were showing very low girth increments of the order of 0.3 inches on mean girth of 35.5 inches. The fertiliser treatments applied in 1947 and 1949 were not affecting the rate of growth.

Effect of fertilisers on growth in nurseries – The effect of fertilisers on the growth of young immature plants has been studied in

nursery and replanting experiments. At the Experiment Station the nursery experiments were designed to compare rates, frequencies, and methods of applying various fertilisers to newly planted nursery seedlings. Fertilisers did not have any marked effects on growth, but growth generally was backward owing to adverse growing conditions, caused by dry weather and leaf disease. In the early stages of growth the rubber seedlings, on height measurements, showed slight benefits from fertilisers applied on the surface just after planting. In one nursery experiment mulching with cuttings of lalang grass was without benefit to the rubber plants.

Effect of type of fertiliser and method of application – A comparison of types of phosphate fertilisers and their methods of application was commenced in 1948, Experiment RW 2. Rock phosphate and superphosphate were applied to replanted budded trees in pockets and by surface broadcasting. The trees, which were budded in 1938, were showing no differential growth response to the treatments to date.

Methods of applying fertilisers, in pockets and on the surface were compared in a replanting experiment on coastal clay soil, and produced no differential effect on the girth of the buddings at the age of two years.

EFFECT OF FERTILISER ON SEED PRODUCTION

The weekly counts of seed production in Field 6 at the Experiment Station were repeated for the full period of seed fall from July to October and showed that potash manuring produced the highest number of seed. This result is different from that obtained in 1948, when for a limited period at the end of the seeding season, the seed counts were greatest from trees receiving phosphate. There is no obvious explanation for this difference; further recording of seed production will be undertaken.

EFFECT OF FERTILISERS ON YIELD

The most important problem in the manuring of young mature rubber trees is to ascertain how soon a tapped tree should receive fertilisers in order that its yield level shall be maintained at a maximum as long as possible. Little is known about the yield responses to fertilisers of high yielding trees, and the majority of the mature rubber manuring experiments of the Soils Division are directed towards various aspects of this problem. The yield records so far available are too few to permit any generalisation, but

for the majority of the individual areas under experiment, yield responses are not detectable in any of the manuring treatments.

Out of sixteen experiments examined, for which yield records are available for periods varying from one to twentythree months (seven experiments had records for a year or longer), significant effects of fertilisers were detectable in three only. One was Field 6 at the Experiment Station, where on a very sandy soil potash was beneficial and phosphate had depressed yield; the other two were on a coastal clay soil, in which potash had slightly depressed the yield, and on an inland soil (lateritic clay loam) where phosphate manuring had slightly improved the yield.

It appears that the response of high yielding rubber to fertilisers will not be great, at least in the early productive years, and that maintenance of yield level is all that can be expected of manuring unless an area shows specific signs of nutrient deficiency. For an area of normal young mature rubber in tapping, it may be advisable to await the first signs of foliage deterioration before embarking on a manuring programme. On the evidence at present available it appears that manuring done before this stage is reached must be regarded as a form of insurance, the value of which remains to be demonstrated by later performance.

III

CULTIVATION AND COVER CROPS

WEEDKILLERS

Investigations on the control of covers by weedkillers were continued, and field tests were specially concerned with the control and eradication of lalang grass (*Imperata cylindrica*). Where there is a moderate amount of shade from existing young rubber trees lalang can be successfully eliminated by spraying with sodium arsenite solutions in water for about eight rounds, after which normal lalang patrols are sufficient to prevent any further regeneration of the weed. Areas of sheet lalang in the open do not respond so readily to spraying with sodium arsenite. A greater number of sprayings is required and must be followed by a varying amount of digging or forking before the land is clear of the grass.

Little work was done on the control by spraying of weeds other than lalang. Siam weed (*Eupatorium odoratum*) was treated

with sodium arsenite spray at the Experiment Station. Large separated clumps of the weed were sprayed with two per cent sodium arsenite solution, two sprayings being given at one month's interval. Although all green growth was suppressed for three to four months, the plants were not completely killed and regeneration occurred. The possibility of killing Siam weed with other weed-killers is to be tried.

The extent to which arsenic accumulates in the soil after spraying was studied. Soils from areas at the R.R.I. Experiment Station which had been sprayed with arsenic confirmed earlier laboratory percolation tests of arsenic solutions through columns of soil. On most soils, rapid fixation of arsenic can be expected in the top one or two inches of soil, and even on the sandy loam soil of the Experiment Station there appears to be little penetration below three inches. The soils analysed had been given the following spraying treatments:

a $2\frac{1}{2}\%$ sodium arsenite solution sprayed at the rate of 60 gallons per acre on sixteen occasions over a period of seven months; soil samples were taken five months after the last spraying.

b 1% sodium arsenite solution sprayed at the rate of 60 gallons per acre on seven occasions over a period of three months; soil samples were taken within a month of the final spraying.

The accumulation of arsenic (As_2O_3) amounted to about 200 p.p.m. in the top inch of soil for site *a* and to about 100 p.p.m. for site *b*.

Although arsenic in the above amounts may be expected, observations in sprayed areas on the growth of rubber trees, whether old or newly planted, indicate that it is in a form unavailable to plants and that rubber trees are not likely to be adversely affected.

Effective strength of arsenical sprays - The use of spreading agents, which reduce the surface tension effect between the leaf surface and the spray fluid, has been generally practised wherever weed control by spraying has been undertaken, and tests have been made with several spreading agents available in Malaya. The effectiveness of the spreader corresponds to the lowering of surface tension which it produces, and it has been found possible to reduce the effective concentration of sodium arsenite in spraying solutions from $2\frac{1}{2}\%$ to 1% by the inclusion of a spreading agent.

Although the reduction in the amount of arsenic used in each spraying round is welcome, the use in widespread spraying operations of such a dangerous poison as sodium arsenite introduces hazards to human and animal health. Much stricter regulations governing the importation, sale, storage, transport and use of arsenic have been enacted in order to reduce these hazards, but there are still situations, for example when there is danger of contamination of drinking water supplies, in which the use of arsenic for spraying must be prohibited. There are urgent reasons, therefore, to seek satisfactory non-poisonous substitutes for sodium arsenite as a weedkiller. In this connection a large number of substances have been tested, either singly or in various combinations, but without notable success. The chemicals used have included the following: pentachlorphenol and its sodium salt, soda ash, caustic soda, 2,4-dichlorphenoxyacetic acid (sodium salt), sulphuric acid, diesel oil, aromatic oil, sodium trichloracetate and ammonium sulfamate, sometimes in combination and with a range of spreaders. With the exception of the last two compounds, no outstanding successes have been obtained. Both sodium trichloracetate and ammonium sulfamate give effective control of lalang after single sprayings, but the quantity of chemical used has been large and the cost prohibitively high. Further tests are being devised with solutions of lower concentration.

A number of spraying units are now available, both hand and power operated and although no comparative tests of different types of spraying equipment have been made, the use of high pressure low volume sprayers should lead to considerable economies.

Observations on open areas of lalang on some estates show that conditions do exist in which lalang may be superseded in natural succession by other less objectionable plants. The process is slow but may have some value in practice for areas under heavy lalang, which may not be planted with rubber for several years. The fire hazard in such areas is the most disturbing factor in preventing the successful establishment of other plant species which will replace lalang. Discussions have taken place with officers of the Forest Research Institute, Kepong, and as a result a long term experiment has been started in which selected plant species (supplied by the Forest Research Institute) are being planted in sheet lalang. Seeds, stumps, and cuttings are being used; seeds are broadcast and cuttings and stumps are planted without point. To date, stump plantings of certain species appear to have the best chances of survival.

IV

MECHANICAL CULTIVATION

One of the main incentives to develop mechanical methods to replace manual labour during the postwar period has been the reduction in costs. At first this applied particularly to the removal of old rubber trees in preparation of land for replanting operations. Tree poisoning with sodium arsenite has, however, proved so successful and so much cheaper that it promises to become the standard method of dealing with the old stand in replanting. Although there is an initial economy in using a poisoning method for removing old trees the full account cannot be computed until the replantings are several years old. Incidence of root disease, entailing expensive control, and other unforeseen developments, may change the cost picture with time. Where root disease appears in the young replanted rubber, the accepted method of treatment involves the removal of the source of infection, *i.e.* the old rubber root or stump. There is little doubt that the cost of removing such diseased material is considerably greater in the presence of the young replants than when done as a part of the preparation and replanting operation.

On the other hand, if mechanical methods are used to remove the old stand of trees, full consideration must be given to possible damage to the soil and loss of fertility. These are most likely to occur on steeper slopes and on soils which erode readily.

Thus, whilst mechanical clearing of old rubber trees may give way to cheaper methods of disposal of the old stand the procedure may have to be modified in relation to root disease treatment.

Observations were made on estates where mechanical cultivation of the soil has been successfully employed. On one estate an area of hilly land (granite, loam to clay loam soil), covered with lalang and a few belukar bushes, had been successfully planted with rubber. Widely spaced terraces (hedge planting) had been cut by a D-8 caterpillar tractor using a bulldozer blade, the width of the terrace being approximately 12 ft. Two 'rooting' operations followed by hand picking of roots had achieved almost complete eradication of the lalang on the terraces. Further invasion by the lalang remaining on the intervening slopes was controlled by making a trench at the back of each terrace, — also effective as an anti-erosion measure — and by occasional spraying of the lalang with sodium arsenite along the front edge of the terrace. Between terraces a steady succession of plants was gradually appearing and should eventually replace the lalang. Growth of the young rubber

plants was normal, and the clearing was expected to reach maturity at a reasonably low cost.

Another successful mechanised operation on moderately hilly land under belukar was accomplished with a large 48 inch rotary hoe. Planting strips were prepared, approximately 10 ft wide, by making three runs with the machine. Although this type of work must be considered 'heavy duty' for the rotary hoe, economies in hand labour and in time were considered to have outweighed such disadvantages as heavy wear and tear on the machine.

A further series of operations seen on a coastal estate indicated the precautions required when using heavy machinery on flat land on heavy clay soils. A D-8 caterpillar tractor had been employed to fell old rubber trees. The large lateral roots and boles of the trees had removed considerable masses of soil when the trees were pushed over. The resulting holes became full with water in wet weather and were difficult to fill; this greatly interfered with subsequent tractor movements. Additional difficulties, due to the rains, were caused by the wetness and difficulty of burning the piled brushwood and small branches, and by the drains blocking and becoming inoperative through the movement of the tractors. The observations made in this instance lead to the conclusion that in wet weather it is inadvisable to use heavy mechanical equipment in field work on flat heavy clay soils with a high water table.

V

LABORATORY

During the year alterations and additions to the laboratory were effected. Extra accommodation for field assistants was provided by partitioning one of the larger rooms. Air conditioning of the balance room was completed early in the year, and the Beckmann pH meter and the Spekker photoelectric absorptiometer are now kept in it. With temperature ranges from 21°C to 24°C and relative humidity variations reduced to 58% to 60% it is anticipated that delicate electrical apparatus should remain free from trouble for long periods in this room. Fume cupboard arrangements were greatly improved about the middle of the year by rebuilding and extension which increased working space and improved the direct lighting. A double entrance door and a small ante-room effectively prevent any leakage of fumes into the main laboratory. Apparatus and chemicals received during the year indicated that

many of the postwar shortages and difficulties of supply have now been overcome.

Further use was made of the Neubauer technique, modified for paddy seedlings, for assessing available plant foods in soils. Differences in fertility status were detectable, based on the uptake of potash and phosphate by the paddy plants, particularly between coastal alluvial soils and inland soil types. The recovery of phosphate which had been added to soils was found to decrease with increasing time of contact between fertiliser and soil. The technique is of value for special problems, but is not suitable for routine examinations.

Micro-methods of analysis for nitrogen determination in soils and in plant material were tested with satisfactory results and were found to be adequate for use in routine analyses for advisory purposes. Improvements were made in the routine analysis of potash in fertilisers, and work continued on the determination of available phosphate in lateritic soils in an endeavour to find a procedure which will give improved discrimination between soils as regards their phosphate status.

Rapid colorimetric methods in the analysis of plant tissues were tested in order to reduce the labour of routine laboratory analyses; for the routine determination of magnesium a colorimetric method has been adopted. Unsuccessful attempts were made to determine calcium and potassium in extracts of plant tissue by rapid turbidimetric methods. Plant tissue tests using Nicholas' technique were investigated, but the results obtained were not completely satisfactory.

Leaf analysis of a number of rubber leaf samples was carried out in connection with yellowing and chlorosis in young rubber, which was widespread throughout the country. Although other factors may be associated with this foliage abnormality, chemical analysis indicates an extremely low magnesium content in the leaves. Field tests are being laid down to study treatment which will correct the chlorotic tendency.

Arsenic in soils was estimated in connection with the use of sodium arsenite as a weedicide and this is referred to on page 9. An attempt was made to investigate the possibility of arsenic appearing in the latex as a result of absorption by the rubber tree after its use in weedkilling operations. Owing to difficulties in developing a successful laboratory technique for the analysis of the latex, no satisfactory results were obtained. Whilst the appearance of arsenic in latex would be highly undesirable if the latex is used to produce rubber goods which are in contact with foods,

it is improbable that dangerous amounts of arsenic could pass into the tree without producing obvious signs of physiological damage.

The use of arsenic for poisoning and killing rubber trees as a preliminary to replanting is now a well established practice, but the advisability has been queried of using wood from poisoned trees for household cooking purposes. The determination of arsenic in a typical poisoned tree from the R.R.I. Experiment Station was therefore undertaken. The tree had been poisoned eight months previously by ringbarking and applying sodium arsenite and tapioca paste. The samples were taken from the roots, trunk, branches and twigs. Arsenic found amounted to about 5 parts per million (As_2O_3) throughout the tree, except in the region of application of the paste. It appears safe to use the stem and branches of poisoned trees as firewood for cooking purposes, provided that the wood at the poisoning point, and just below it, is avoided.

Arsenic in leaf samples from recently poisoned trees has been determined, and considerable variation in the amounts translocated into the leaves has been noted. Effective tree poisoning results in a rapid discoloration of the leaves to a brownish green within a few days, and such leaves may contain appreciable traces of arsenic.

These analyses for arsenic in the rubber tree support the view that the death of the poisoned tree arises from loss of leaves and from damage to the conducting tissues of the wood at the point of application, resulting in the interruption of supplies of moisture and nutrients.

Rubber seedlings grown at the Experiment Station in an atap shaded nursery (See *Pathological Division* '49, page 24) showed an interesting healthy dark green foliage in comparison with much paler leaves, suffering from bird's eye spot disease, of plants in an adjoining nursery in the open. Soil and leaf analyses were made on samples taken from both areas on five successive mornings. Nitrate nitrogen and ammoniacal nitrogen in top soil (0 to 2 inches) and in subsoil (2 to 6 inches) showed no consistent differences between the two nurseries. Total soil nitrogen was consistently higher for the open nursery than for the shaded nursery. Although leaf nitrogen was higher for shaded nursery plants, the difference was too small to account for the colour difference between the leaves.

For the purpose of comparison with results published in the Journal*, a further sampling and analysis was made of a normal

* *J. Rubb. Res. Inst. Malaya* 9 (1939) 6, 14

mature rubber tree at the Experiment Station. The soils of the two areas where the trees had been growing were quite different, and appreciable differences between the two trees were recorded, both in bulk and in concentration of plant foods.

Further work on soil phosphate studies was undertaken at the end of the year and exploratory investigations were made in an attempt to develop a method for fractionation and differentiation of types of soil phosphorus.

ADVISORY WORK

A SLIGHT INCREASE WAS RECORDED in the amount of correspondence sent out from the Division. The numbers of visits paid to estates and to the Experiment Station, as well as interviews with visitors to the Institute, showed a considerable increase over those for 1948. The statistics relating to correspondence, visits and interviews are summarised below:

Letters sent out	
Estate experiments	285
Replanting	44
Manuring	234
Weedkillers	100
General estate practice	237
R.R.I. Experiment Station	50
Miscellaneous	41
Total	991
Visits made	
Estate experiments	26
R.R.I. Experiment Station	67
Advisory	79
Total	172
Interviews at the Institute	183

Analysis of the working time of senior officers in the Division showed that 50 per cent of time was spent on research, 40 per cent on advisory work. The balance of 10 per cent was taken up with routine and administrative matters.

The principal problems arising in advisory work related to replanting techniques, the use of fertilisers for young and old rubber trees, the control of lalang grass and other covers by means of herbicidal sprays, and the treatment of cover plants in rubber areas.

Among the many postwar replantings which were inspected, numerous instances were noticed where the growth of the young rubber plants was indifferent or backward. An attempt is being made to assess the conditions underlying such backwardness, although it is apparent that it cannot be assigned to any single factor. Strict economies have been practised in many postwar replantings, particularly with regard to hand cultivation and to the types of cover crops used and their control. These practices, combined with unsuitable weather conditions and planting material of variable quality, are suspected to be the major causes of the backward development, rather than deficiencies of soil plant foods, or fertilisers.

Lack of girthing in young mature areas has often been complained of, but this is more likely to be due to high stand and insufficient thinning out, combined with early tapping, than to lack of manuring.

Foliage abnormalities have been particularly noticed in young replantings in many parts of the country, and considerable interest has been shown by estates in the use of magnesium fertilisers to correct leaf yellowing. The interveinal yellowing that has been observed in rubber leaves is similar to that which in a number of other crops is usually associated with magnesium deficiency. While observations on some areas showing leaf yellowing indicate that a magnesium limestone application is often followed by a recovery of normal leaf colour, it is by no means established that the interveinal yellowing is caused by a magnesium deficiency in the soil. The yellowing has been most frequently associated with buddings of clone PB 86, and P.B.I.G. seed. Field experiments, which will be supported by laboratory work, are being planned to investigate the effects of different sources of magnesium on leaf discolouration.

In an effort to minimise the expense of replanting, some estates have attempted to obtain the maximum crop from the old rubber trees by retaining them in tapping during the early growth of the young replants. Observations made on such areas suggest that excessive retardation of the young plants usually occurs, which will eventually delay maturity of the replanted tree to an extent which cannot be compensated by the extra yield obtained from retaining the old trees. It is considered that by planning replanting reasonably in advance the extra latex can best be obtained by fully exploiting all the bark reserves of the old stand of trees before the new stand is planted.

Confirmation was obtained of the generally accepted belief that young rubber plants cannot tolerate alkaline soil condition, when soil conditions were examined in a poorly developed nursery where plants suffered from pale green and chlorotic foliage. Soil and leaf analysis showed that poor growth was due to the alkaline soil, which was derived from limestone rocks.

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Kuala Lumpur

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STAFF

ALL THREE SENIOR OFFICERS in the Division were on duty throughout the year, but efforts to recruit a fourth officer continued to be unsuccessful.

Several changes were made in the junior staff; three new laboratory assistants were appointed, but with two resignations occurring at the end of the year this section of the staff gained a net increase of only one. One additional field assistant and one additional laboratory attendant were appointed. At the end of the year, the staff consisted of three senior officers, ten laboratory assistants, ten field assistants, two laboratory attendants, and one peon.

INVESTIGATIONS

I

SOIL SURVEY

Opportunities for examining and sampling soil profiles in the field were rather limited during the year, and the total profiles from which soil samples were collected amounted to thirtythree. Of particular interest were those obtained from an area derived from rhyolite ash which is a parent material of comparatively rare occurrence. Samples of North Borneo soil profiles were examined and a comparison based on analytical data and field descriptions was made between them and Malayan soils.

II

MANURING OF HEVEA

In spite of continued interference by bandits with the normal routine on rubber estates in many parts of the country, there was practically no disruption of experimental work; on two experimental areas only was recording work interrupted. Experiments were terminated on five estates and six new ones were commenced.

Growth measurements were taken in eightyfour areas, and at the end of the year monthly yield records from thirtyfour experiments were being received. Fertilisers were applied according to programme on twentyfour experiments.

The fertiliser trials which are now being carried out by the Soils Division on rubber trees planted from jungle and on replanted trees may be summarised as follows:

a factorial* manuring, with N, P, and K fertilisers at two levels (2 x 2 x 2) and at three levels (3 x 3 x 3); a few trials include four fertiliser levels;

b non-factorial designs using arbitrarily chosen fertiliser combinations;

c factorial experiments mainly concerned with phosphate fertilisers, comparing levels and qualities of phosphate manures and methods of application;

d trials to test the effect of magnesium on foliage and on leaf discoloration;

e replanting trials comparing holing and cover crop cultivation treatments;

f soil cultivation and manuring in old rubber;

g annual *v* biennial manuring with nitrogen (sulphate of ammonia).

The main group of experiments is concerned with determining the fertiliser requirements of young mature trees in tapping. The experimental areas are sited on rubber estates in different parts of the country and cover a wide range of soil types. Nearly all areas have received two applications of fertilisers since 1946, and the responses of the trees to manuring treatments are being determined by annual girth measurements and monthly yield records.

The responses of younger trees to fertilisers during their early growth have been fully reported,† but the records which are accumulating for trees during their early years of maturity are revealing comparatively little response to date. The different groups of experiments are briefly commented upon in the succeeding paragraphs.

Factorial 2 × 2 × 2 comparisons of nitrogen, phosphorus, and potash fertilisers — A total of seventeen experiments fell under this heading, ten being with rubber trees planted from jungle land and the remaining seven being replantings. Recent girth increments showed, in one instance, a positive response to phosphorus manuring on an inland soil (granite) for one year out of three, and there was a suggestion, not proved, that yields might also be benefitting

* *A statistical term referring to the design of experiments. Factorial experiments include all combinations of several different sets of treatments or 'factors'. The responses to these different sets are investigated simultaneously.*

† *J. Rubb. Res. Inst. Malaya* 12 (1950) 167

from the phosphate manuring. On a coastal clay soil, girth increments for one year out of three showed a small benefit from nitrogen manuring, but there was no corresponding increase in yields. In a replanting experiment on a granite soil type a positive response to phosphorus was shown in the yields of rubber for the first three months of recording. 'Suggested' (not proven) effects of fertilisers on yields and on girth increments were appearing in three other experiments. In a replanting trial on very sandy soil, height measurements during the first year of growth showed responses to nitrogen manuring.

Factorial 3 × 3 × 3 comparisons of nitrogen, phosphorus, and potash fertilisers — Eight experiments in this category were in progress. They included four on jungle land and four replantings. The experiments on older trees (six) which were in tapping did not show any response to fertiliser treatments, either in yield or girth increment, during recent years. In one replanting experiment on very sandy soil, phosphorus manuring increased heights and girths of young seedlings (as measured by numbers of plants ready for budding), but there was a suggested nitrogen effect (not proven) which appeared to be harmful.

Non-factorial designs, six treatment series — Six experiments come under this class, including the long established ones in Field 6 and Field 31 at the R.R.I. Experiment Station, and it is only in Field 6 and Field 31 that any yield effects have been established.

On the very sandy alluvial soil of Field 6, yields have been significantly improved by the treatments using cattle manure and 'complete' chemical fertilisers, and also by the phosphorus and potash combination of nutrients; nitrogen alone has been without benefit, and the nitrogen phosphorus fertiliser has significantly depressed yields below that of the unmanured trees.

(During 1950, the thirtysix plots of this experiment were subdivided for superimposing new treatments on half plots, to obtain more information on the individual effects of potash and phosphorus on the twenty year old trees.)

On the hill area in Field 31, with a fine textured sandy loam soil, the trees were first tapped when ten years old in 1947, on a full spiral system every fourth day; although the yields in 1948 showed no proved responses to fertilisers, those for 1949 gave significant yield improvements with NPK and NP manuring.

Other experiments – Of the twentythree experiments that come under this heading, records were available for only short periods, and the effects of fertilisers on yield could not yet be adequately

assessed. In only one instance did any significant difference between treatments appear in the girth increments. On a coastal clay soil, young replanted trees of two to three years of age appeared to be responding better to fertilisers which are placed in pockets than when spread on the surface.

In one other experiment there is a suggestion that a high level of phosphate manuring (up to 4 lb rock phosphate per tree) may be harmful.

Thus there are still insufficient data upon which to base definite conclusions, and the general trend of the information available indicates that little immediate response to fertilisers can be expected in young mature trees which have had some manuring during their first few years of growth.

Nurseries – A number of manuring trials on nursery plantings at the R.R.I. Experiment Station were concluded during the year but the amount of information obtained, and consequently the value of the results, was considerably reduced by the generally poor growth of the plants which suffered from severe attacks of bird's eye spot leaf disease (*Helminthosporium heveae*). Even where treatment effects appear to have been beneficial they have not appreciably raised the plants above the general level of backwardness. The indications obtained from four experiments on a gritty loam soil may be summarised as follows:

1 fertilisers may be expected to improve growth;

2 the main benefit is due to the phosphate component of the fertiliser;

3 rock phosphate is slightly more effective when placed in drills about two inches deep on each side of the plant row, than when spread on the surface;

4 it was not possible to detect differences in growth when fertilisers were applied immediately before and after planting;

5 mulching with lalang grass or mikania creeper was not beneficial.

Small scale tests at the R.R.I. Experiment Station with magnesium fertilisers on young seedlings, which exhibited symptoms assumed to be those of mild magnesium deficiency, produced no definite responses either to magnesium lime applied in the soil or to magnesium sulphate sprayed on the foliage.

Observations in a nursery, and examination of soil samples from it, gave confirmation of the widely held view, that rubber seedlings will not grow under alkaline soil conditions. The nursery was sited close to limestone cliffs, and where the calcareous soil

had an alkaline reaction (pH 8.0 approx) the rubber seedlings quickly developed yellow foliage and failed to grow.

Growth of young mature budgrafts — Girth records of buddings from a large number of Soils Division experiments have been assembled according to clones and age, and TABLE I summarises the measurements. The increments are of the same order as those obtained for 1948 to 1949, and, whilst generalisations are liable to be too strictly applied to individual cases, it does appear that for budded rubber, which is in normal health and which is being tapped, an annual girth increment of about three quarters of an inch may be expected at sixty inches above the union for trees whose age is 10 to 12 years and whose girth is about 26 or 27 inches.

TABLE I: MEAN GIRTHS OF TREES IN SOILS DIVISION EXPERIMENTAL AREAS IN 1950
(in inches at 60 inches)

Year budded	*Clone PB 86*	*Clone Pil B84*	*Clone Tjir 1*	*All clones*
1937	26.78 (6)	27.78 (5)	28.81 (5)	27.09 (6)
1938	26.74 (8)	27.06 (5)	27.58 (9)	26.89 (10)
1939	26.26 (8)	26.71 (11)	27.53 (7)	26.74 (12)
1940	24.39 (1)	24.76 (3)	27.59 (2)	25.83 (4)
Mean	26.48 (23)	26.76 (24)	27.83 (23)	26.73 (32)
Replantings (1937-'40)			27.27 (7)	26.18 (10)
MEAN GIRTH INCREMENTS (1949-1950)				
1937	0.59 (3)	0.75 (2)	0.51 (2)	0.61 (3)
1938	0.67 (8)	0.63 (5)	0.73 (9)	0.72 (10)
1939	0.85 (7)	0.79 (10)	0.97 (7)	0.83 (11)
1940	0.95 (1)	0.97 (3)	1.11 (2)	0.91 (4)
Mean	0.74 (19)	0.78 (20)	0.80 (20)	0.78 (28)
Replantings (1937-'40)			0.81 (7)	0.77 (10)

The figures in brackets indicate the numbers of experiments from which the mean girth is derived

Average girth measurements compiled before the war indicated that budded rubber trees of approximately 10 years of age should increase in girth from between one to two inches a year, and on this basis numerous young mature fields of budded rubber have been assessed as below normal vigour and development. The measurements quoted in TABLE I, however, demonstrate that buddings grow at a much reduced rate on attaining maturity and being tapped, and that between half an inch and one inch girth increment during early maturity may be taken as satisfactory.

III

CULTIVATION AND COVER CROPS

WEED KILLERS

The main work done under this heading was concerned with the control of lalang and weeds by means of herbicides other than sodium arsenite. Whilst sodium arsenite as a spray liquid has the advantages of effectiveness and cheapness, its poisonous properties, which may be a danger to human beings and to animals, and the supply problem necessitated a search for alternative weedkillers. Increasing labour charges were causing estates to consider using spraying methods in place of the traditional weeding by hand for upkeep of young clearings, and although sodium arsenite is effective for this purpose in most instances, there are indications that supplies of the chemical were not sufficient to meet these extra demands.

Lalang control — Several forms of 4,6-dinitro-ortho-cresol (DNOC) have been used for spraying lalang, including both the sodium and the ammonium salts and the phenolic form in oils. Solutions up to 5% strength and applying 25 lb per acre were used. They were all quite ineffective for controlling lalang.

Pentachlorphenol and its sodium salt have been used both in oil and in water solutions supplying up to 8.4 lb per acre of the chemical, and once 30 lb per acre of the sodium salt was sprayed. Compounds of 2,4-D have been included as fortifying agents. The results of the tests have shown that pentachlorphenol compounds are not effective for killing lalang.

Considerable interest has been taken by estates in the possibilities of oil spraying for lalang control. Tests have been carried out on standing lalang growing in the open with two types of oil — the diesel fuel types and other types with a high aromatic oil content — and mostly the oils were sprayed at the rate of 60

gallons per acre. Although the lalang was quickly browned and was slower to regenerate than when sprayed with sodium arsenite, it was found to be making appreciable new growth even after six sprayings. Fortification of the oils with pentachlorphenol or 2,4-dichloro-phenoxyacetic acid compounds failed to give any better results.

Emulsions of oils in water, including several proprietory formulations containing up to 45% oil, have also been without any marked success. Attempts were made to produce satisfactory emulsions of oils and water using emulsifiers at present available in this country. Considerable difficulty was experienced, and no simple method was discovered which can be repeated by unskilled labour on estates. It would appear, if oil emulsions are to be prepared and used under ordinary estate conditions, that the oil concentrate containing emulsifier and fortifying compounds and already emulsified must be available for direct dilution with water.

Tests have been started in which the lalang has been slashed to ground level and the oil sprays applied to the newly regenerating shoots when they are about twelve to eighteen inches high. Preliminary results show that there is appreciable regeneration after four rounds of spraying. From the results so far obtained, oil spraying has not proved to be noticeably more effective than spraying with sodium arsenite, but they do show that it is much more expensive.

Very limited quantities of sodium tri-chloractate (T.C.A.) and ammonium sulfamate (Ammate) have been available for tests as weedkillers, and results with these chemicals when used on lalang have been promising, although the prices at which these compounds are likely to be available make them too expensive for general use. T.C.A. is more persistent in its effect than Ammate, and with the former a single spraying at 15% strength, with 1% Fernoxone included, will suppress lalang for about two months. At a spraying rate of 60 gallons per acre 90 lb of T.C.A. per acre were applied. With the cost of this herbicide at $1.75 per lb, it was still far from competing with the cheaper sodium arsenite. Ammate, although less costly, is less effective and requires two or three sprayings at the above concentration to achieve a similar effect. Where T.C.A. has been used and fresh lalang shoots appear, they quickly turn from pale green to brown, due to the toxic effect of the chemical persisting in the soil.

In dilute solutions, T.C.A. is reputed to be toxic to both annual and perennial grasses and tests will be made to determine its value for routine weeding maintenance in young areas.

The sodium salt of 2,4,5-trichlorphenoxyacetic acid (2,4,5,-T) in aqueous solutions has been sprayed on standing lalang without any appreciable effect.

Lalang control by shade — Attempts have been made to establish tree covers in lalang, using the minimum preparation of the ground. The plots were one chain square and seeds were sown broadcast at the rate of 2,000 per plot, except for cashew nut seeds which were spaced two feet apart. Where planting rows were used they were six feet apart and planting was done at four feet intervals along the rows. TABLE II summarises the results to date. The Batai trees grown from stumps appear to be most promising and the effect on the lalang of the ground shade, which will increase as the trees develop, will be observed.

TABLE II: LALANG CONTROL BY SHADE

Tree	*Material planted*	*Survival*
Anacardium occidentale (cashew nut)	*seed planted*	*80% germination, many eaten by rats; negligible survival*
	seedlings planted	*15% survival after eighteen months*
Albizzia falcata (Batai)	*seed broadcast*	
	stumps pushed into the ground	*79% sprouted; 41% survived after ten months*
Acacia auriculijormis	*seed broadcast*	*nil*
	seedlings	*nil*
	seedlings in soil pads	*nil*
Jemerelang	*seed broadcast*	*nil*
Styrax benzoin (Kemanyan)	*seed broadcast*	*nil*
	seedlings planted	*nil*
Fagrea fragrans (Tembusu)	*seedlings planted*	*45% survival after eighteen months*
Melia azadrachta	*seeds broadcast*	*nil*
Casuarina equistifolia	*small seedlings*	*nil*
	large seedlings	*nil*
	seedlings in soil pads, in small holes 6 in x 4 in	*60% survival after one month; 48% survival after seven months*

Control of other covers — In an area of young rubber trees about two years old, strips of mixed covers were sprayed with solutions of Ammate and T.C.A. without obtaining any marked killing. The covers consisted of mixed bushes with some creepers

(*Mikania scandens*) and a few light grasses, and whilst some of the low growing herbs and creepers were apparently killed, the upright bushes suffered no serious harm. The grasses were appreciably affected. Carpet grass (*Axonopus compressus*) in the open was effectively killed when sprayed with a 10% solution of T.C.A. at the rate of 100 gallons per acre, which is the dosage recommended by American workers. Bracken (*Gleichenia linearis*) under mature rubber was not affected by 10% T.C.A. or 10% Ammate solutions, but was effectively 'browned' by aromatic oil and by 1% sodium arsenite solution. More extensive work is required and is being planned on the use of weedkillers as a substitute for changkol weeding in young clearings.

Damage from sodium arsenite spraying — Investigation of the cause of the sudden death of young rubber seedlings about one month after planting showed that the prolonged and heavy spraying of lalang and other covers over nearly two years prior to planting was most probably the chief reason for the trouble. Up to 500 lb per acre of sodium arsenite had been used, which is much in excess of the quantities normally applied; and in a somewhat sandy soil where ground water drainage was rather restricted owing to land contours, toxic amounts of arsenic had accumulated in a form which could be absorbed by the rubber seedlings.

IV

MECHANICAL CULTIVATION

Observations of field cultivation procedures on estates involving the use of machines have continued, and a cultivation and manuring experiment was commenced in a mature budded rubber area at the Experiment Station.

The object of the latter experiment was to determine whether the cultivation of soil between the rows of old rubber trees by means of disc harrows and disc ploughs is beneficial or otherwise. The cultivation treatments were combined with a factorial manuring using N, P, and K fertilisers. Possible benefits which may be expected are (*a*) the efficient incorporation in the soil of leaf and root material (the cultivation was done when leaves shed during 'wintering' were on the ground); (*b*) stimulation of rubber root development following root pruning; (*c*) more effective use of fertilisers by incorporation with the soil. There is also the possibility of a harmful reaction due to root damage, which may reduce the

vigour of the tree and increase the incidence of root disease. The manuring and cultivation treatments are being repeated annually.

From the monthly yield records which have been taken, both ploughing and harrowing seem to have had a temporary depressing effect on yield. This was not unexpected because with the disc harrow operating to a depth of four to six inches and the disc plough operating to eight or ten inches depth, an appreciable amount of damage to large rubber roots was observed. The ploughing produced a mild inversion of the soil, and both cultivation treatments resulted in the germination of cover crop seeds (*Centrosema pubescens*) which had lain dormant in the soil for nearly twenty years. The experiment was continued.

Full consideration has been given to the possibilities of adapting hedge trimming machines for routine cover control work on rubber estates. Details of a number of mechanical hedge cutters of widely different design were received from England, together with opinions from the National Institute of Agricultural Engineering. None appears really suitable for controlling covers on typical rubber areas in Malaya, where the slope of the land, the uneven surface of the ground and the occurrence of obstructions in the form of logs and stumps, are the biggest difficulties to be overcome. It appears to be most desirable for estates to take a very long term view regarding future labour availability when making preparations for replanting or new planting. Upkeep of mature areas by hand may become increasingly difficult and expensive, and planting distances should be adopted which, by having sufficiently wide spacing between rows, *e.g.* 30 ft or more, will permit the manoeuvring of tractors and equipment between rows.

On flat land in alluvial clay soil, effective use has been made of a small type of rotary hoe for controlling dense creepers and grasses along the edges of the weeded tree rows in a three year old replanting. In addition to reducing the competition effect from the covers, the cultivation has also improved the physical condition of the soil by producing a tilth not normally found in coastal clay soils. A general stimulation of growth of the rubber trees has resulted, but obviously the treatment must not be continued too long because of the increasing amount of damage to the rubber roots which will occur as the trees grow older.

A possible economy in replanting operations has been attempted on one estate by using a single pronged chisel, attached to a light tractor, for cutting through the roots of old rubber trees before they are poisoned. The chiselling is done twice along two paths about one foot apart in the centres of the old planting

rows and on a light textured soil is expected to obviate the need for holing.

V

LABORATORY

Extensive laboratory investigations were in progress during the year, and adequate supplies of chemicals and apparatus were available. Consideration was given to the construction of a pot culture shed: advice was sought from other research institutions in different parts of the world, but final plans for the building were not completed.

Summary of Laboratory Work

	Samples	Determinations
SOILS SURVEY		
Mechanical and chemical analysis	537	9301
Clay fractions	136	861
ADVISORY		
Soils	639	2924
Leaf samples	146	1607
Fertilisers	21	152
Weedkillers	5	14
Miscellaneous	15	38

METHODS OF ANALYSIS OF SOILS AND PLANT MATERIAL

Much of the laboratory work was devoted to testing and comparing methods of soil analysis chiefly for the determination of different forms of phosphorus in the soil.

Total phosphorus in soils — A study of several methods was undertaken to compare the quantities of phosphate removed from soil by different extracting liquids and also to reduce the labour involved in estimating phosphorus in the extracts. In the routine procedure practised in this laboratory diluted hydrochloric acid (1 : 1 in water) is used for extraction of phosphorus, whereas concentrated hydrochloric acid is employed in the standard method generally mentioned in the literature. For Malayan soils the diluted acid has extracted the same amount of phosphorus as the concentrated acid. The same extracts were used for potash determinations, and again equal quantities of potash were obtained with either extractant.

Several procedures were tested for estimating the total phosphorus. In the method developed by Shelton and Harper extraction of phosphorus is done with perchloric acid and the phosphorus in the solution is determined colorimetrically. Results obtained with this method were erratic and the recovery of added phosphorus was variable. The method of Armstrong-Black has been found more satisfactory, although preliminary treatment with potassium permanganate for oxidising soil organic matter was not found to be necessary. The extracted phosphate was estimated colorimetrically using both stannous chloride and hydrazine sulphate as reducing agents for developing the molybdenum blue colour. Both reagents were equally satisfactory.

The colorimetric method has not proved to be appreciably more rapid than the standard volumetric method, which has been retained as the method for routine analysis using hydrochloric acid (1 : 1) as the extracting solution.

Available phosphorus in soils — A critical examination has been made of some of the methods most commonly used for determining 'available' phosphorus in soils. The importance of phosphorus in the nutrition of the young rubber tree has been well established and there is evidence that additions of phosphorus fertilisers may benefit older trees. It is desirable that the amounts of phosphorus in soils which are available for the nutrition of the rubber trees should be known and then to determine the limiting values below which the growth of the tree will be restricted. The standard methods of estimating available soil phosphate, by extracting it with dilute acids, are not satisfactory when used on Malayan soils because they give extremely low values. These do not differentiate adequately between soils which respond to additions of phosphatic fertilisers, and those which show no response.

A close examination was made of Truog's method of estimating available phosphate (by extraction from the soil with dilute sulphuric acid) which has always been used, with certain minor modifications, in this laboratory. While it has the merit of simplicity and rapidity, and results are reproducible, it does not give results which allow for a reliable assessment of the relative phosphorus supplying abilities of local soils because values for all soils are very low and fall within a narrow range. A modification of Neubauer's technique, using paddy seedlings as the indicator plant, also proved rather unsatisfactory mainly because results were not reproducible under the conditions in which the procedure was carried out.

Consideration was then given to estimating the different forms in which phosphorus is present in the soil. Anion exchange reactions in the soil must play an important role in the phosphorus nutrition of plants and, recognising this, methods were examined for distinguishing between the adsorbed and acid soluble forms of soil phosphorus.

Adsorbed and acid soluble phosphate fractions were determined in a number of soils by a method, based on a procedure developed by American workers, in which the different fractions are extracted with solutions of ammonium fluoride. It was found that a large proportion of the soil phosphorus is present in the adsorbed form, a form which is not readily soluble in dilute acids. The sum of the adsorbed fraction and the acid soluble fraction is regarded as a measure of phosphate effectiveness. The values obtained by the ammonium fluoride extraction method were compared with the single values for the readily available phosphate as obtained by the Truog and by the Neubauer methods. There was a close correlation (statistically significant) between all values but values obtained by the fluoride extraction methods correlated best with the Truog values. However, the magnitude and range of the values determined by extraction with the fluoride solutions are considerably greater than those of the Truog values and thus allow for a more reliable estimate of a threshold value. Moreover, the former values reflect much bigger differences between soils which are known to respond to treatment with phosphate and those which do not, thus allowing for a more reliable assessment of the phosphate status of different soils.

The data available on growth, yield and general performance of rubber trees on different Malayan soil types is insufficient to enable us to relate the values for the phosphate content of the soils to the growth and production of the rubber trees grown on them. The only information available at this stage, which can be used as a reliable basis for comparing soils in which the available forms of phosphate are adequate with those in which they are inadequate for optimum growth, is that the majority of inland soils respond to treatment with phosphate while most of the coastal alluvial soils show no response. A summary showing the values obtained for the readily available phosphate by different methods in the two groups of soils mentioned is shown in TABLE III. These mean values reflect the known general difference between inland soils and coastal alluvial soils in their phosphate supplying capacity. On the basis of these results a figure of 40 p.p.m. for the total of adsorbed and acid soluble phosphate in local soils (determined by extraction

with fluoride solutions) may be regarded tentatively as the limit below which a response to phosphate manuring can be expected.

TABLE III: AVAILABLE PHOSPHATE IN SOILS

Mean values calculated as P_2O_5

Soil	*Fluoride extraction*			*Truog value p.p.m.*	*Neubauer value mg/100 gm*
	Total avail. phos. p.p.m.	*Adsorb. phos. p.p.m.*	*Acid sol. phos. p.p.m.*		
INLAND					
All samples (51)	19	12	7	5	0.677
Surface soils (24)	26	17	9	6	0.974
COASTAL ALLUVIAL					
All samples (22)	57	33	24	9	1.139
Surface soils (13)	68	41	27	9	1.213

The figures in brackets indicate the numbers of samples from which the mean values have been calculated.

Determination of phosphorus in plant material — Methods for determining phosphorus in plant material were examined. A satisfactory technique was developed using a colorimetric method which gave close agreement with results obtained by the volumetric procedure, good recovery of added phosphate, and a quicker and simpler procedure. Smaller samples of leaves and less chemicals can be used.

Determination of potash — A detailed study was made of the standard method of estimating potassium in solution, by precipitation as cobaltinitrite and titration with permanganate solution, with particular reference to assessing more acurately the factors which contribute to the variability of results. The conclusions reached were that although slightly more complete precipitation of the cobaltinitrite complex may be obtained at refrigerator temperatures (35° to 40° F), satisfactory results can be obtained at laboratory working temperatures (80° to 90° F) by using the factor 0.3926 (Brown's factor) for conversion of millilitres of N/20 $KMnO_4$ to milligrams K_2O. Rapid methods of determining potash in soils and plant material including a turbidimetric method and a colorimetric

method were tried but none of the methods proved completely satisfactory.

Exchangeable magnesium in soils — The colorimetric method of Drosdoff and Nearpass for estimating magnesium in plant material has been successfully adapted for estimating exchangeable magnesium in soils.

Analysis of soil clay fractions — In order to reduce the labour involved in the chemical analysis of soil clays, an examination was made of rapid colorimetric methods for the estimation of silicon, aluminium, iron and titanium. Efforts were made to develop a satisfactory technique for the determination of all four elements in the one solution. None of the methods tested gave consistently accurate results for the contents of silica and aluminium but the standard colorimetric method for estimation of titanium, using hydrogen peroxide as the reagent for developing the colour, proved satisfactory and a suitable technique for the accurate determination of iron was eventually developed using ammonium thiocyanate as a reagent.

For clay samples so far examined the titanium content has been consistently higher in clays separated from soils derived from basic rocks than in those separated from alluvial soils and soils derived from acid rocks. Thus determination of the titanium content of the clay fractions may serve as a means of distinguishing soils derived from basic rocks from those derived from other parent materials.

SOIL PHOSPHATE STUDIES

Variability of soil phosphorus within samples from the same area — An estimate of the variability of phosphorus in soil from a given area was made by sampling over widely separated unmanured plots in a manuring experiment on an estate. Several samples were taken from each of five plots, one acre in size and distributed over a block of 40 acres. All values for 'available' phosphate were very low while values for 'total' phosphate were more variable but the differences, either between plots or between samples within a plot, were not statistically significant.

Availability of different phosphatic fertilisers when added to soils — Laboratory tests were started to determine the availability of phosphate fertilisers at increasing intervals of time after addition to soils. The readily soluble fractions of the added phosphorus are being determined by extraction with fluoride solutions. A few days after the addition of phosphates had been made the proportion present in readily available form varied from 5 per cent in a

highly ferruginous soil derived from basic rocks to about 62 per cent in a sandy loam derived from sandstone. The degree of fixation was least for Christmas Island rock phosphate. After three months, readily soluble phosphate had decreased slightly in all soils except the sandy loam, and the reduction was greatest where Christmas Island rock phosphate had been applied.

Fractionation of soil phosphorus — Towards the end of the year work was commenced to study the distribution of various forms of phosphorus in soils. The fractions studied are:

Inorganic, acid soluble, phosphorus;
Inorganic, alkali soluble, phosphorus;
Organic phosphorus;
Insoluble compounds ('inert' fraction).

Preliminary work has been done on the methods of determining the various fractions and the main difficulty lies in the determination of phosphorus in coloured soil extracts.

Other investigations — These included the determination of the effect of plant nutrients on latex production, by the extraction of the rubber hydrocarbon from rubber seedlings grown for one year in sand receiving nutrient solutions; the investigation of fluctuations of ammonia and nitrate nitrogen in soils; the use of *Aspergillus niger* for the assessment of available soil nutrients.

SPECIAL PROBLEMS

Analyses in connection with: determinations of total and available phosphorus in soils, fractionation of soil phosphorus, determination of phosphorus in plant materials, determination of potassium and exchangeable magnesium in soils, estimation of available plant nutrients in soils by Neubauer and by *Aspergillus niger* methods, colorimetric estimation of silica, iron, aluminium and titanium in soil clays, estimation of ammonia nitrogen and nitrate nitrogen in soils, total nitrogen in samples of legume covers submitted by Pathological Division.

ADVISORY WORK AND OTHER ACTIVITIES

THE VOLUME OF CORRESPONDENCE and the numbers of visits to estates were both higher than in the previous year. Advisory work was attended to by two officers, one of whom spent two thirds of his time and the other over one third of his time under this heading.

The statistics relating to correspondence, visits and interviews may be summarised as follows:

Letters sent out	
Estate experiments	328
Replanting and manuring	304
Weedkillers and lalang eradication	97
Covers crops	24
Mechanical cultivation	22
Laboratory analysis	24
R.R.I. Experiment Station	47
General	71
Miscellaneous	141
Total	1058
Visits made	
Estate experiments	34
R.R.I. Experiment Station	52
Advisory	84
Miscellaneous	10
Total	180
Interviews at the Institute	175

The subjects about which advisory letters and visits were mostly concerned were as in previous years: principally manuring problems for rubber trees of all ages; economic aspect of manuring old rubber trees; replanting; control of covers and the use of weedkillers; establishment and manuring of legume covers. Estates were coming to consider the application of fertilisers as an insurance of the continued good health of the trees rather than as a measure to be adopted only when obvious signs appeared that extra nutrition was required.

In a number of instances of advisory visits, when advice on manuring problems has been sought, it has been observed that other agricultural features require attention, such as drainage, cover control, thinning out and tapping intensity. Until such matters have been improved fertilisers will not produce their maximum effect.

Further observations have been made on backward growth of plants which was of common occurrence in postwar replantings, in spite of normal care and attention and regular applications of fertilisers. The backwardness is characterised by leaf disorders and defoliation and an almost complete cessation of growth. A number of factors appear to be responsible for the poor growth, including

poor soil conditions, wrongly placed fertiliser applications, unsuitable covers and inadequate weeding control, and sometimes a deficiency of available magnesium.

An interesting instance of damage to young rubber plants caused by fertilisers was observed in a replanted area at the R.R.I. Experiment Station. Fertilisers were applied when the seedlings were six months old, and immediately leaf scorch and defoliation occurred on a certain number of plants. The affected leaves showed either a partial scorching or browning, or at the worst a complete loss of chlorophyll which produced a colourless transparent leaf. Defoliation followed the loss of colour in the leaf, but no permanent damage resulted and new leaves were eventually formed. The fertilisers used included 5 oz sulphate of ammonia and muriate of potash, and the rubber seedlings were growing in partial shade on a very sandy soil. The cause of the trouble was diagnosed as too high a salt concentration in the zone of root development which resulted in damage to the root system. Attempts to produce the same effect by similar manuring in a nursery of young seedlings were not successful.

Tours of visits lasting several days were made in nearly all States, including Johore (4), Negri Sembilan (2), Perak (4), Kedah (3) and Kelantan (1). An address entitled 'The Manuring of Rubber' was given by the Soils Chemist (W.H. Williams) to the Negri Sembilan branch of the Incorporated Society of Planters on 26 October 1950.

On two occasions officers of the Soils Division prepared sets of questions, and marked the answers, for the examinations held by the Incorporated Society of Planters.

In September the Head of the Division attended an inaugural meeting held to discuss the formation of a Malayan Scientific Advisory Council.

PUBLICATIONS

THE FOLLOWING PUBLICATIONS were issued during the year:

Replanting Fertiliser Programme	Circular No. 30
Note on Backward Replanting	Circular No. 31

C.G. AKHURST and G. OWEN Manuring Experiments on Young Rubber Trees. I. Effect of Fertilisers on Growth *J. Rubb. Res. Inst. Malaya* 12 (1950) 167 Communication 267.

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Head of Soils Division

Kuala Lumpur

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STAFF

THE HEAD OF THE DIVISION was away from Malaya on long leave for seven months (14 May to 14 December) and the Soils Chemist (W.H. Williams) left for Europe on long leave on 2 November. The appointment of an additional Soils Chemist (G.M.F. Grundy) was made towards the end of the year, and a course of study on tropical soils at the Imperial College of Tropical Agriculture in Trinidad was arranged for him before his taking up duties in Malaya in the beginning of 1953. There was an increase of one clerk/typist in the junior staff strength, which at the end of the year amounted to ten laboratory assistants, ten field assistants, one clerk/typist, two laboratory attendants and one peon.

INVESTIGATIONS

I

SOIL SURVEY

There was little field work done during the year, and twenty profile pits were examined and sampled. Reports were prepared on soils from 'dry' rubber areas in North Borneo and on soils from a group of field manuring experiments in the area of North Johore, Malacca, and Negri Sembilan.

II

MANURING OF HEVEA

Interference in field experiments by bandit activity was experienced on several estates where manuring experiments are being carried out. Trees were slashed or cut down on five areas, in two of which further experimental work had to be given up. In two other experiments all recording work ceased temporarily until conditions become more settled. New schemes of manuring experiments on mature rubber were commenced in three estates where experiments had existed before the war. At the Experiment Station three fertiliser experiments on newly planted rubber were commenced, one being a permanent long term trial and the others being only for a short period, up to a year from planting. Fertiliser applications were made in twentyone experiments, and for many of them this

completed the third biennial application since the war. At the end of the year yield records were being received from fortythree experiments, and growth measurements had been recorded in sixty-four trials.

Manuring of rubber seedlings in a nursery has shown that rock phosphate applied at 1.6 oz per running yard (equivalent to 1.8 cwt per acre) increased the percentage of plants which were ready for budding at one year from planting. Doubling the rate of application was without any extra advantage. There was some indication, not proven, of beneficial effects due to nitrogen and potash, but no differences were found between nitrate of soda and sulphate of ammonia. When rock phosphate was applied in a narrow drill about two inches below the surface along each row of plants it was rather better than when spread evenly on the surface of the soil. Comparison was made between mulching of the soil surface with cuttings of lalang (*Imperata cylindrica*) and with *Mikania scandens*, and although not definitely established, the mikania appeared to be beneficial whereas lalang was not.

Fertilisers applied to rubber seedlings in a newly planted area were beneficial to growth during the first year after planting, and the percentage of plants ready for budding was increased by all treatments, including that of sulphate of ammonia alone. The main effect was due to phosphate and differences with various fertilisers containing the phosphate were not significant. The superiority of organic *cum* inorganic mixture, although it was significantly better than the sulphate of ammonia, was not proven over inorganic mixtures.

Growth increments for young mature rubber trees over one year and two year periods were statistically analysed from twenty-three experiments. Most of the trees were budded in 1938 to 1940, and with one exception two applications of fertilisers had been given at the time of the last girth increment. Girth increments were found to be significantly affected by manuring in five instances, and individually are summarised as follows:

i all manured plots were improved in comparison with unmanured plots; differences for levels of nitrogen and of phosphate could not be demonstrated; no effect of potash could be detected (Ribu, replanting, inland soil);

ii a marked response to nitrogen was detected for 1949/50 but not for 1950/51, fertilisers having been applied in March 1948 and in March 1950; there were indications of a beneficial effect due to phosphate

during the first period, and in the second period the response was sufficient to satisfy the requirement for statistical significance; no effect due to potash could be shown (Sungala, replanting, inland soil);

iii significant treatment effects due to nitrogen and to phosphate were established for the period November 1949 to November 1950, fertilisers having been applied in October 1947 and August 1949 (Batu Anam, inland soil);

iv girth increments, March 1950 to March 1951, were adversely affected by potash manuring, fertilisers having been applied in 1948 and 1950; a beneficial effect due to phosphate was indicated but not proven. (Bukit Rajah, alluvial organic clay);

v a negative interaction was observed between nitrogen and phosphorus manuring for girth increments from March 1950 to March 1951, manures having been applied in 1948 and in 1950; evidence of interaction between potash and burning was shown, in that potash appears to restrict girth increments in unburned plots but has a beneficial effect in the burned area. The terms 'burned' and 'unburned' refer to the methods of clearing jungle before planting with rubber (Mengkibol, inland soil).

The analyses of girth increments in the remaining eighteen experiments failed to reveal any effect due to manures.

The conclusion from this evidence is that for young mature budded rubber trees, aged 11 years to 13 years from budding, girth increments which were taken after the second fertiliser application had been given since tapping commenced failed to show any marked or consistent effect due to fertilisers. This applies both to replantings and to rubber planted from freshly cleared jungle.

Statistical analyses of yield records were made for twentyfour experiments where the trees were 11 to 14 years old. Fertilisers have been applied since the war on two occasions in most experiments, prior to the period for which yields have been reviewed. The effect of manures on yields has only been significant in six cases, which are individually referred to below:

i in a replanting experiment (Sungala) on an inland soil type, positive linear responses to nitrogen and to phosphate manuring were recorded for yields covering the period December 1949 to November 1950, manures having been applied in March 1948 and

March 1950; the trees were replanted and budgrafted 1938 to 1939.

ii in a replanting experiment (Wardieburn III) on an inland soil type, yields for the period May 1950 to April 1951 show a positive response to phosphate fertilisers; there is also an indication, not proven, of a positive interaction effect between nitrogen and potash manures; the trees were replanted and budgrafted 1937/38 and fertilisers were applied in March 1948 and June 1950.

iii in an experimental area (Bukit Panjang) on coastal alluvium clay soil, budgrafted in the early thirties, a significant positive nitrogen/potash interaction was detected in yields for the period February 1950 to January 1951, which was the first year following the second application of fertilisers in April 1950; this positive effect was not confirmed in the yields taken for the succeeding twelve months.

iv an unusual effect appeared in the yields (July 1949 to June 1950) from an experiment (Mengkibol) where the two halves of the area, totalling 100 acres, were differentiated by felling and burning the jungle in one half and by felling without burning in the other half; no responses to fertilisers were detected but a significant interaction between potash manuring and burning appeared; the trees were budgrafted in 1938, and postwar manuring was done in July 1948 and June 1950.

v yield records for 1948, 1949 and 1950 from the manuring experiment in Field 31, R.R.I. Experiment Station, were examined in some detail and significant responses to fertilisers were detected. The earlier established effects of fertilisers on growth are now being repeated with respect to the yields, although the effect on yield is only gradually appearing, because it was not apparent in the 1948 yields.

In 1949, both NPK and NP treatments gave significantly improved yields, and in 1950 NPK treatment was again significantly higher than the control, though NP treatment just failed to reach the significant level.

Thus although the experiment has not a factorial design, the influence of fertilisers on yield appear to

be due mainly to nitrogen and phosphorus. The apparent lack of effect of potash is of interest because the soil is a light sandy loam derived from sandstone parent rock and the use of potash might be expected to give beneficial results. The trees in this experiment were budded in 1937, and postwar manuring was done in July 1947 and April 1949.

vi although detailed analyses of recent yields have not been made, the records for the manuring experiment in Field 6, R.R.I. Experiment Station, continue to follow the trends already well established, *viz* significant positive yield effects from cattle manure and NPK fertiliser treatments, and negative yield effects with nitrogen phosphorus fertiliser treatment. The soil a very sandy loam.

In the remaining nineteen experiments responses to fertilisers were not detected, although a few records gave suggestions or strong indications of responses which were not significantly established. Whilst the conclusion must be the same as in previous years, *viz* that postwar manuring has produced little effect on the yields, there is an indication that more definite responses are beginning to appear. It is therefore anticipated that the completion of the full manuring programme in 1952 of three biennial applications will enhance the yield trends which so far have been only suggested or indicated in the records obtained. The first cycle of tapping of trees in the experiments will soon be coming to an end, and clearer definition of effects may follow when renewed bark is tapped.

III

CULTIVATION AND COVER CROPS

During the first part of the year the testing of herbicides for control of weeds developed as a search for a suitable formulation to emulsify oil with water containing fortifying weedkillers. Previous work had shown oils, sodium trichloracetate, and ammonium sulfamate to be effective but uneconomically expensive for controlling lalang, and no cheap emulsifying agent was available which produced easily prepared emulsions of these chemicals with oils and water. It was always found that the cheaper Diesel fuel type of oil was less easy to emulsify than the 'aromatic' oils. Small quantities

of satisfactory emulsions were prepared by a homogenisation process, and were used for preliminary tests on lalang and grass in micro-plots.

Observations were completed in an experiment with lalang using an 'aromatic' type of oil, which has reputedly a higher toxicity rating as a weedkiller than Diesel fuel types. Five successive sprayings were given at monthly intervals. Up to 60 gallons per acre per spraying had no permanent killing effect on the lalang, which was slashed down and the cuttings removed before the initial spraying. The inclusion of 1% 2,4-D was without effect.

Oils have been more effective on lalang than on less upright and creeping grasses, with which they react more as contact herbicides, quickly killing the grass blades above ground, but having relatively little penetration into the roots. Oil concentrations of less than 15%, in emulsions with water were found to be without effect on lalang and grasses. Adequate coverage of the vegetation was obtained if a minimum of 100 gallons per acre of spray was used.

Tests with sodium trichloracetate (T.C.A.), using 10, 20, and 30 lb per acre, and sodium pentachlorphenate (P.C.Ph.), in aqueous solutions indicated that a combination of the two chemicals substantially enhanced the effect of each on lalang and grasses, particularly at lower concentrations. The inclusion of the sodium salt of 2.4-D did not give any better result. The tests made at the R.R.I. Experiment Station have shown that emulsions of oil and water fortified with T.C.A. and P.C.Ph. can control lalang, though there remains to be found a more convenient method of preparing the emulsion and the optimum concentrations of the fortifying chemicals.

Observations continued on the control of lalang by the shade of other plants. Of the planted tree species, Batai (*Albizzia falcata*) and *Casuarina equistifolia* have been the most rapid growers. Few of the other planted species became established. There was, however, a noticeable change over two years in the general character of the natural vegetation of the test area, and the previously small and isolated plants of *Eupatorium odoratum*, *Melastoma polyanthum*, and *Mikania scandens* became the dominant species in parts of the area. If fires, which destroy the non-lalang species, can be avoided, there is a reasonable chance that lalang in the open can be replaced by natural successions of plants.

Further trials on controlling Siam weed (*Eupatorium odoratum*) by chemical weedkillers showed that it was not seriously affected by 1% sodium T.C.A. in water, by 0.35% sodium salt of

2,4-D in water, or by 0.25% sodium salt of 2,4,5-T in water. Trioxone (a mixture of esters of 2,4-D and 2,4,5-T) used at 0.25% strength in 15% oil emulsified with water was very effective in killing Siam weed.

IV

MECHANICAL CULTIVATION

One of the main features of mechanised operations being carried out by estates has been the increasing use of tractor drawn implements for eradicating lalang over large areas of land. A detailed inspection was made in North Johore where land (700 acres) under mixed jungle and lalang has been prepared for cultivation. Initially, after timber had been cleared and stacked, heavy pronged rippers were pulled through the soil to remove large roots and also to expose lalang roots. then a single ploughing with a disc plough was given. Operations were completed with a Ferguson tractor using disc or tine harrows; two rounds of harrowing broke up large soil clods with further exposure of lalang roots. after which it was possible to plant cover crops and rubber seedlings. The procedure has successfully eradicated lalang, and regular maintenance of the whole area has only been possible by using medium tractors and light cultivation equipment.

Land which was under lalang at the R.R.I. Experiment Station was prepared for planting in a similar manner. Because of previous clean clearing and food crop cultivation there were no timber and stumps to be cleared and stacked before starting to disc plough and harrow. A system of hedge planting was to be used, with 60 feet between the 'hedges', so planting strips 12 feet wide were first treated, and two sets of operations were needed to clear the lalang. The lalang remaining between the planting strips was left for eradication during the first year after planting. To prevent invasion of the cleared strips by lalang roots from the adjoining uncleared belts, isolation trenches about nine inches deep were changkolled along each edge of the planting strip. This method of preparing lalang land for planting with rubber proved effective, quick, and economical.

The second annual cultivations with disc harrows and disc ploughs, and applications of fertilisers, were carried out in the experiment in Field 15, R.R.I. Experiment Station. An estimate

made of the amount of leaf litter on the soil surface before ploughing commenced gave a figure of 3.4 cwt per acre, but only part of this can be considered to be effectively incorporated in the soil by ploughing and harrowing. Whilst the damage caused to root systems of the rubber trees by the ploughing treatment appeared to be severe, no appreciable effect on yield from the trees was observed during the year following the first cultivation treatments. This experiment continued.

A demonstration was seen of the Fisher-Humphreys hedge slasher, which consists of a large toothed circular saw blade and revolves around a vertical axis. The machine is tractor drawn. The demonstration emphasised the difficulties to be experienced in using such implements on any but level ground.

V

LABORATORY

During the year a number of new methods of analysis were investigated in connection with routine analyses of soils, of fertilisers and of plant material, and also in connection with the different investigations being carried out. The methods examined were concerned with the determination of (*i*) different forms in which phosphorus occurs in soils, (*ii*) free iron oxide in soil, (*iii*) available soil nutrients by bio-assay methods (*Aspergillus niger*), (*iv*) rubber hydrocarbon in rubber plants.

Summary of Laboratory Work

	Samples	Determinations
SOILS SURVEY		
Mechanical and chemical analysis	308	6692
Clay fractions	25	200
ADVISORY		
Soils	204	1702
Leaves	133	1808
Fertilisers	21	54
Plant materials	7	30
Miscellaneous	13	36
INVESTIGATIONS		
Fertiliser mixture variations	32	296
Ammonia and nitrate in soils	372	2244
Available nutrients: Aspergillus	36	737
Neubauer	52	420

(contd.)

INVESTIGATIONS	Samples	Determinations
Phosphate studies	nil	1606
Pot culture plant analysis	nil	644
Fertiliser leaching	150	675
Exchange cations	2	51

Fractionation of soil phosphorus compounds — Various methods were tried for estimating the forms of phosphorus in soils, based on the use of a series of selective extracting solutions. The method advocated by Wrenshall and Dyer, which uses hydrochloric acid and ammonia, and by Dean, which involves sodium hydroxide and dilute sulphuric acid, were first tested but were discarded later in favour of C.H. Williams' modification of the Ghani method, which uses acetic acid with 8-hydroxyquinoline and sodium hydroxide. These extractants differentiate the following fractions:

1 acid soluble fraction, containing phosphates readily available to plants

2 alkali soluble fraction, composed of both inorganic and organic forms of phosphorus, of which at least a part can be utilised by plants

3 insoluble in either extractant and considered to be almost wholly inert

A study was made of the distribution of these forms of native phosphorus in soils from experimental areas. For inland soils which show a marked response to treatment to phosphates, a large proportion (66 per cent) of the total soil phosphorus is insoluble in either acetic acid or the alkali extractant, and only a small amount (7 per cent) which is considered to be available to plants was extracted as inorganic phosphorus. The organic phosphorus fraction amounted to 26 per cent of the mean total soil phosphorus. In the coastal alluvial soils, which are not responsive to added phosphates, the phosphorus fractions (averages) were 16 per cent in the inorganic form, 35 per cent in the organic form, and 48 per cent insoluble.

The indications are that there are marked differences in the distribution of forms of native phosphorus, as estimated by C.H. Williams' method, between Malayan soils which do respond and those which do not respond to phosphatic manuring. Work on this subject continued.

Availability of phosphate fertilisers when added to soil — A range of soils were treated with four types of phosphate fertilisers (Christmas Island rock phosphate, superphosphate, calcium diphosphate and sodium monophosphate) and the amounts of readily

available phosphate were estimated (Arnold's fluoride extraction method) after six months and after one year. The results obtained show that the amount of recoverable added phosphorus falls with increase of time since the addition was made, and that in the alluvial clays and the sandy soils fixation of phosphorus is less rapid and less complete than in ferruginous loams and clay loams. Certain differences found in the behaviour of the different added phosphates require further examination.

Determination of free iron oxides in soil — The methods of Debb and of Jeffries were compared. Both proved readily adaptable to routine laboratory work, but the former is simpler and less time consuming.

Available nutrients in soil — Work continued using *Aspergillus niger* for determining available phosphorus and potash in soils. Using a Groningen strain of the *Aspergillus*, good differentiation between soils for potash was obtained and a close correlation was found between these values and those produced by the standard chemical methods. The estimates of available phosphorus, however, gave low figures which fell within a narrow range, and the bio-assay method for determining available phosphate offers no advantages over the quicker chemical methods.

Pot culture studies — An experiment was commenced to ascertain the effect of major nutrient elements on latex formation in the young rubber plant. The extraction of the rubber hydrocarbon from rubber seedlings was done by van der Bie's method, and preliminary results indicated that the leaf petiole gave the highest amount of rubber per unit weight of plant material. The total amount of rubber hydrocarbon in the whole plant (roots, stem, petiole and leaves) was equivalent to 0.4 per cent of the total dry weight of the plant.

The plants were grown in washed sand and were fed with various nutrient combinations. Because omission of nitrogen almost inhibited growth, a small basic dosage of this element was given to all treatments to allow plants to survive until harvesting (12 months after planting). Early observations showed that omission of phosphate markedly retards growth but that omission of potash has little effect. The latter observation indicates that very low concentration of potash, such as might be provided by washed sand, may be adequate for normal growth of young plants. Harvesting and analysis of the plants awaited completion of twelve months' growth.

Leaf analysis — The problem of abnormal defoliation of clone BD 5 under Malayan conditions, was examined in respect of a trace element nutrition. Spectrographic analyses of leaf samples were done by the Macaulay Institute, Aberdeen, the samples of clone BD 5 (and of clone Tjir 1 for comparison) being taken from four estates in Malaya. Samples of BD 5 from Java and Indo China, where the foliage is normal, were also examined.

The results of these analyses gave no proof that deficiency or excess of any trace element is responsible for the peculiar condition of the foliage of clone BD 5 in Malaya. No correlation existed between foliage density and the contents of barium, chromium, copper, iron, lead, nickel, tin, vanadium or zinc. There were suggestions that the study of the effect of molybdenum and manganese might merit further consideration. A rather closer correlation was noticed (not in any way significant) between cobalt in the leaves and foliage density, though earlier work by the Botanical Division with cobalt injections on BD 5 trees at the Experiment Station yielded no results.

Soil nitrogen — A study was commenced of soil nitrogen changes under (*a*) no cover (bare) (*b*) leguminous creeper and (*c*) mulch of cut lalang. Weekly determinations of moisture of ammoniacal nitrogen and of nitrate nitrogen were made in samples at 1 inch and from 1 inch to 7 inches depth. No large fluctuations in nitrate nitrogen, such as have been reported in East African soils, could be detected during the year. There was a slight increase during a dry period in the middle of the year in the bare soil plots, but the maximum concentration of nitrate nitrogen was 9 parts per million. The moisture content of soil in covered plots was, as expected, consistently higher than in bare plots.

Leaching of fertilisers through soils — The rates of leaching of fertilisers through columns of soil 8 inches deep were examined. Three types of nitrogenous fertilisers, and sulphate of potash, and ordinary superphosphate (18 per cent) were used and the estimated rate of application was 10 cwt per acre of each fertiliser. Leaching was done at intervals of 4 days for the first month, and thereafter at weekly intervals. The nitrogen fertilisers leached most quickly, nitrate of soda being almost completely lost in the first twenty days, and 95 per cent of nitrogen in sulphate of ammonia being leached in the first forty days. Nitrogen from urea went most slowly, 80 per cent being lost after the fifty days. Of the added potash, 75 per cent leached through after fortysix days, and was most rapid in the presence of sulphate of ammonia. No phosphate percolated.

Variability in composition of random samples of fertilisers — A series of analyses was carried out to examine the variability of the composition of random samples taken from bulk consignments of mixed fertilisers, and to ascertain with what precision one can expect to identify the mixture on the basis of the results of analysis of one or more samples. A sample consisted of a portion of a bulk sample obtained by taking handfuls at different depths in a bag (200 lb) of fertiliser. Consignment *A* consisted of 400 bags, of which 20 bags were sampled, and consignment *B* consisted of 245 bags of which 10 bags were sampled. The reputed compositions of the two consignments, which were from two different sources, were the same *viz* 14.1%N, 7.5% P_2O_5, 7.8% K_2O.

The analyses showed that:

i neither consignment accords with its specification;

ii both consignments were below specification for percentage of nitrogen and above specification for percentage of phosphoric acid (P_2O_5); consignment *A* was above specification for percentage of potash (K_2O) and this value was significantly greater than that obtained in consignment *B*.

The variability between samples was great and was of the same order in both consignments. Mixing of fertilisers on a commercial scale is not sufficiently efficient to allow identification of the composition of a consignment, as a whole, from the results of analysis of a single sample from one bag. The data obtained emphasise the importance of following the officially recommended procedure for sampling.

ADVISORY WORK AND OTHER ACTIVITIES

THERE WAS AN APPRECIABLE fall both in the volume correspondence (by 30 per cent) and in the number of visits made (by 57 per cent) which became more noticeable in the second half of the year when only two senior officers were on duty. The relevant statistics are given below:

Letters sent out

Advisory	353
Experiments	289
Miscellaneous	71
Total	713

Visits made

Estate experiments	23
R.R.I. Experiment Station	25
Advisory	20
Miscellaneous	9
Total	77

Advisory leaflets and memoranda prepared:

S/AL 11(51) Manuring of Nurseries

S/M 27(51) Note on Eradication of 'Lalang' by Spraying with Oils

S/M 32(51) Control of Lalang by Spraying

The Head of the Division visited British North Borneo in January with the Head of the Botanical Division, to investigate cases of 'dry' rubber trees. Samples of bark, leaf, and soil were taken from dry areas in three different parts of the country and a report was made. No reasonable explanation was evolved to account for the peculiar dry condition. One area of dry trees in Malaya was inspected by the Soils Chemist, G. Owen.

The principal matters of interest arising from requests for advice were manuring of young areas, particularly in connection with foliage discolouration and abnormalities in young plants; investigation of suspected magnesium deficiency in a number of estates by means of leaf analysis; appearance of marginal leaf scorch caused by temporary waterlogging of the root zone; value of manuring for maintaining declining yield in old seedling rubber trees; weed control and lalang control in particular, chiefly with sodium arsenite or oil sprays. Inquiries were also received concerning legume establishment and maintenance and the suitability of new land for planting rubber.

An address was given by the Soils Chemist, W.H. Williams, in March to the Malacca Branch of the Incorporated Society of Planters, entitled 'Manuring with special reference to young rubber trees.'

All senior officers of the Division attended discussions at the Latex Symposium held at the Institute, 19 to 21 February 1951.

While on leave in Great Britain, the Head of the Division attended the international conference on 'Some crop protection problems in world agriculture' which was held in June at Fernhurst Research Station.

PUBLICATIONS

THE FOLLOWING PUBLICATIONS were issued during the year:

G. OWEN A Provisional Classification of Malayan Soils *J. Rubb. Res. Inst. Malaya* 13(1951)20 Communication 274

G. OWEN Some Comments on Notes by H.F.W. Gray on Covers and Manuring in Immature Rubber Areas *Planter, Kuala Lumpur* 27(1951)359

A note on manuring of young rubber plants was prepared for the R.R.I. Planters' Bulletin.

C.G. AKHURST
Head of Soils Division

Kuala Lumpur